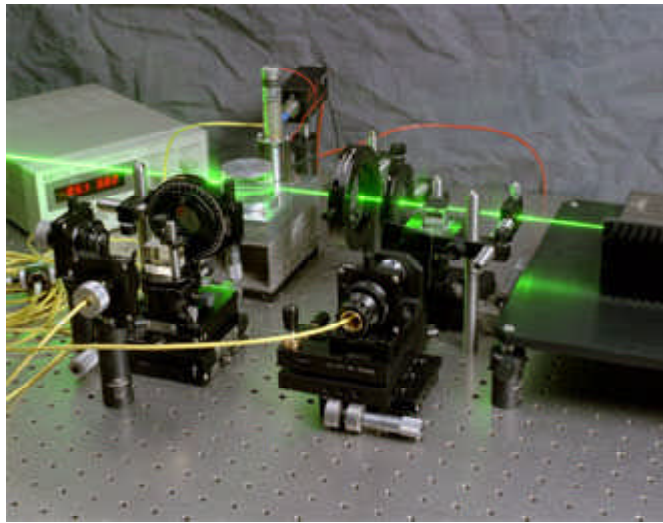


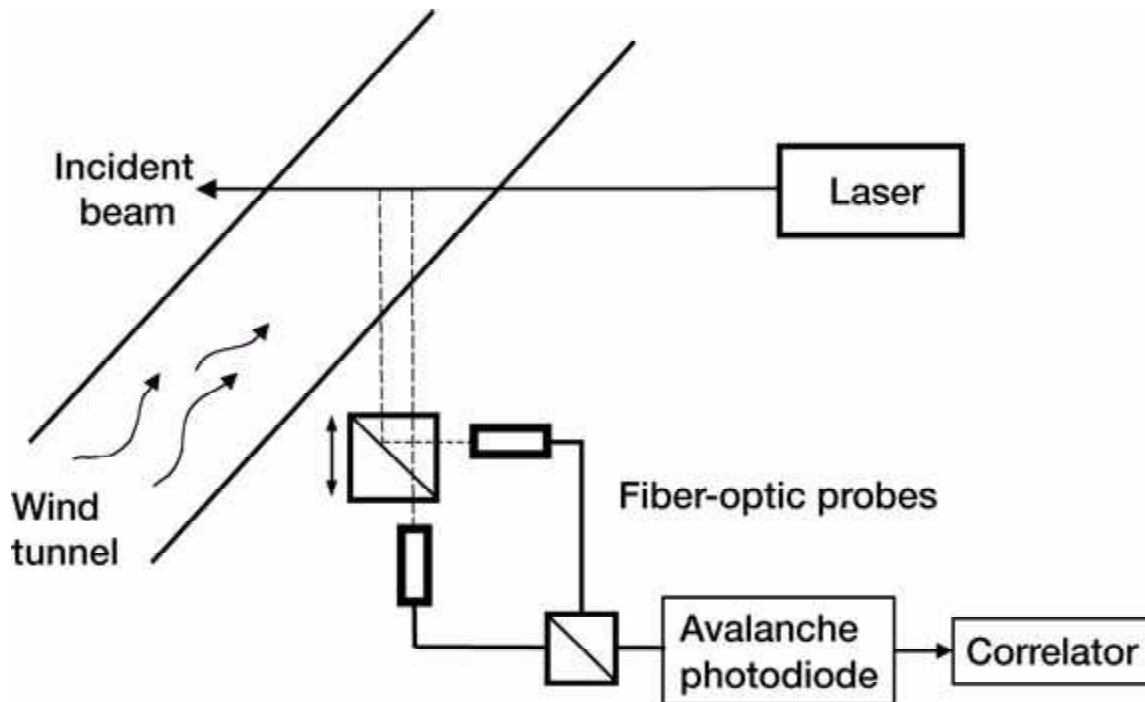
Novel Optical Technique Developed and Tested for Measuring Two-Point Velocity Correlations in Turbulent Flows

A novel technique for characterizing turbulent flows was developed and tested at the NASA Glenn Research Center. The work is being done in collaboration with the University of Pittsburgh, through a grant from the NASA Microgravity Fluid Physics Program. The technique we are using, Homodyne Correlation Spectroscopy (HCS), is a laser-light-scattering technique that measures the Doppler frequency shift of light scattered from microscopic particles in the fluid flow. Whereas Laser Doppler Velocimetry gives a local (single-point) measurement of the fluid velocity, the HCS technique measures correlations between fluid velocities at two separate points in the flow at the same instant of time. Velocity correlations in the flow field are of fundamental interest to turbulence researchers and are of practical importance in many engineering applications, such as aeronautics.



Optical system used to measure two-point velocity correlations in turbulent wind tunnel flows. A small fluid sample is used to align the optics.

In analogy with a police radar gun, which measures speed from the Doppler shift of light reflected from a moving car, the HCS technique uses a laser as the source of "radar," and instead of large moving cars, detects light scattered by micrometer-sized particles that are introduced to the flow from a smoke cartridge. By combining the signals, or scattered light, from two separate points in the flow, the average velocity difference between the points can be measured. When fiber-optic probes are used to collect the scattered light, it is simple to vary the spacing between the two points. With our setup, we can probe velocity correlations at length scales from 0.2 to 32 mm. Measuring the average velocity difference, or correlations, as a function of the distance between the two points yields the structure function of the turbulent flow.



Homodyne Correlation Spectroscopy (HCS) optics. Fiber optics and a beam-splitter cube combine the scattered light from two points along the incident beam. An avalanche photodiode converts the light to an electrical signal, which is analyzed by the correlator.

At Glenn, we tested the HCS technique with fiber-optic probes in a 20- by 20-cm wind tunnel at wind speeds from 2 to 30 m/sec. The incident laser was a 100-mW Nd:YAG laser, focused to a beam width of about 0.2 mm. Regin smoke cartridges (Shelton, CT) were used to produce a large quantity of particles at a near-constant rate. A grid mesh of 1-cm-diameter rods was used to generate the grid turbulence, which is considered a model turbulence system. By varying the wind speed and the spacing between fiber-optic probes, we successfully characterized the turbulence using this technique. Advantages of the HCS technique include characterizing turbulence at small length scales (down to 0.2 mm in our studies), nonintrusive probe of the velocity correlations, and direct measurements of two-point correlations, instead of invoking Taylor's frozen turbulence assumption.

This is the first application of the HCS technique to wind tunnel flows, and we have successfully demonstrated that the HCS technique is a powerful, simple method of characterizing velocity correlations in turbulent flows. The data obtained from the wind tunnel have been analyzed and are currently under review for publication. Some surprising results have emerged from our analysis, which could lead to a new and better understanding of turbulence.

Bibliography

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